

Patent Claims

1. Biometric, acoustic writing system (1) having:
  - 5 (a) a pen housing (3) for making hand-guided movements on a substrate (4);
  - (b) at least one microphone (5), which is integrated in the pen housing (3), for acoustic recording of  
10 sound signals which are caused by the hand-guided movements;
  - (c) and a data processing unit (11) for calculation of biometric data as a function of the recorded sound  
15 signals.
2. Biometric, acoustic writing system according to Claim 1,  
characterized  
20 in that the data processing unit (11) is provided for reconstruction of handwritten characters and texts from the recorded sound signals.
3. Biometric, acoustic writing system according to  
25 Claim 1,  
characterized  
in that a pen (2) is provided in the pen housing (3), is placed on the substrate (4) and is guided on the  
substrate (4).
- 30 4. Biometric writing system according to Claim 3,  
characterized  
in that an interchangeable pen refill with an ink filling is provided as the pen (2).
- 35 5. Biometric, acoustic writing system according to one of Claims 1 to 4,  
characterized

in that the friction of the pen (2) on the substrate (4) during the hand-guided writing movement produces an acoustic writing noise, which is transmitted as a structure-borne sound signal via the pen (2) and as an airborne sound signal via the surrounding air to the microphone (5).

6. Biometric acoustic writing system according to Claim 5,  
10 characterized  
in that the microphone (5) is mechanically coupled to the pen in order to transmit the structure-borne sound signal.

15 7. Biometric, acoustic writing system according to Claim 5,  
characterized  
in that the microphone (5) is mechanically coupled to a sound body (6), which is connected to the pen (2), in  
20 order to transmit the structure-borne sound signal.

8. Biometric, acoustic writing system according to Claim 7,  
characterized  
25 in that the sound body (6) is in the form of a resonator for specific natural frequencies.

9. Biometric, acoustic writing system according to one of the preceding claims,  
30 characterized  
in that the microphone (5) is arranged in an airborne sound chamber (7), which is provided in the pen housing (3).

35 10. Biometric, acoustic writing system according to Claim 9,  
characterized  
in that the airborne sound chamber (7) is in the form  
TRI1\605845v1

of a resonator for specific natural frequencies.

11. Biometric, acoustic writing system according to Claim 10,

5 characterized

in that the microphone (5) and the resonator are surrounded by sound insulation (8), which is intended to attenuate environmental noise and passes sound signals only via the writing refill.

10

12. Biometric, acoustic writing system according to Claim 9,

characterized

15 in that the airborne sound chamber (7) can be coupled to the surrounding air via a housing opening which is provided in the pen housing (3).

13. Biometric, acoustic writing system according to Claim 12,

20 characterized

in that the housing opening can be closed by means of a mechanical closure device (9) in order to suppress external noise.

25 14. Biometric, acoustic writing system according to Claim 12,

characterized

30 in that, when the housing opening is open, the microphone (5) acoustically records the internal and external writing noise which is caused by the hand-guided writing movement as a structure-borne and airborne sound signal and/or acoustically records a speech signal which originates from a person.

35 15. Biometric, acoustic writing system according to Claim 1,

characterized

in that the microphone (5) converts the recorded

TRI1\605845v1

acoustic sound signals to an electrical sound signal.

16. Biometric, acoustic writing system according to Claim 15,

5 characterized

in that the electrical sound signal is converted by an analogue/digital converter to sound signal data for digital data processing by means of the data processing unit (11).

10

17. Biometric, acoustic writing system according to Claim 14,

characterized

15 in that the writing noise and the speech signal are recorded simultaneously or successively by means of the microphone (5).

18. Biometric, acoustic writing system according to Claim 14,

20 characterized

in that the sound signal data can be stored in a memory unit (12).

19. Biometric, acoustic writing system according to Claim 1,

25

characterized

in that the writing substrate (4) is composed of any desired paper.

20. Biometric, acoustic writing system according to Claim 1,

30

characterized

35 in that the writing substrate (4) is a fixed substrate which has a specific pronounced surface roughness and hardness.

21. Biometric, acoustic writing system according to Claim 1,

TRI1\605845v1

characterized  
in that a loudspeaker (32) is provided in the pen  
housing (3) in order to reproduce recorded microphone  
signals, in order to reproduce stored biometric  
5 reference data, and in order to reproduce spoken  
information.

22. Biometric, acoustic writing system according to  
Claim 1,  
10 characterized  
in that a microphone (5) is provided in the pen housing  
(3) in order to record external acoustic signals such  
as writing noises from the writing substrate as sound  
body, and spoken information.

15 23. Biometric, acoustic writing system according to  
Claim 1,  
characterized  
in that a pressure sensor device is additionally  
20 provided, which records the static and dynamic writing  
pressure in at least one spatial direction of the hand-  
guided pen which has been placed on the substrate.

24. Biometric, acoustic writing system according to  
25 Claim 23,  
characterized  
in that an additional oscillation sensor device is  
provided, which records oscillations and thus changes  
in the writing speed of the hand-guided pen which has  
30 been placed on the substrate (4).

25. Biometric, acoustic writing system according to  
Claim 27,  
characterized  
35 in that an inclination sensor (40) is additionally  
provided, which, during writing, records the  
inclination of the pen (2) and thus the motor movement  
of the finger which is guiding in the pen.

TRI1\605845v1

26. Biometric, acoustic writing system according to Claim 1, characterized

5 in that a first optical sensor device (48) is also provided, which records the static and dynamic pressure and the oscillation of the hand-guided pen (2), which has been placed on the substrate (4), in three spatial directions at the same time.

10

27. Biometric, acoustic writing system according to Claim 26, characterized

15 in that a second optical sensor device (33) is additionally provided, which records position data for the hand-guided pen movement via image signals from the surface of the substrate (4).

20 28. Biometric, acoustic writing system according to Claim 1, characterized

in that a capacitive fingerprint sensor (39) is provided on the pen housing (3).

25 29. Biometric, acoustic writing system according to Claim 1, characterized

30 in that the microphone (5) is an electret microphone, a piezoelectric microphone, a piezoresistive microphone or a capacitive microphone.

30. Biometric acoustic writing system according to Claim 27, characterized

35 in that the first optical sensor device (48) has photodetectors in order to record the movement of a first diode light source (44) and in order to convert the light source signal to an electrical signal.

TRI1\605845v1

31. Biometric acoustic writing system according to Claim 30,  
characterized

5 in that the first optical sensor device (40) has first  
imaging optics, which comprise a beam splitter (47), an  
optical partially reflective lens (46) and a shutter.

32. Biometric writing system according to Claim 30,  
10 characterized  
in that the first optical sensor device (40) has a  
four-quadrant photodetector (50) and a single  
photodetector (45).

15 33. Biometric writing system according to Claim 32,  
characterized  
in that the four-quadrant photodetector (50) records  
the deflection and oscillation of the light source (44)  
in mutually orthogonal x, y directions.

20 34. Biometric writing system according to Claim 32,  
characterized  
in that the single photodetector (35) records the  
deflection and oscillation of the light source (44) in  
25 the direction z at right angles to x, y.

35. Biometric writing system according to Claim 30,  
characterized  
in that the first diode light source (44) is firmly  
30 connected to the pen (2) and carries out its deflection  
and oscillation, with the light beams which are emitted  
from the diode light source (44) being emitted as light  
source signals to the photodetectors.

35 36. Biometric writing system according to Claim 32,  
characterized  
in that the dynamics of the writing pressure can be  
determined via the deflection, and the dynamics of the

writing speed can be determined via the oscillation, in three spatial directions from the signals from the four-quadrant photodetector (50) and from the single photodetector (45).

5

37. Biometric writing system according to Claim 27, characterized in that the second optical sensor device (33) has second imaging optics for imaging of the substrate surface and has a converter device for conversion of the optical imaging signal to an electrical signal.

10

38. Biometric writing system according to Claim 37, characterized in that the second imaging optics comprise optical lenses and/or glass fibres.

15

39. Biometric writing system according to Claim 37, characterized in that the converter device is a mini-CCD camera or a photodiode array.

20

40. Biometric writing system according to Claim 27, characterized in that a second diode light source is provided in order to illuminate the substrate surface.

25

41. Biometric writing system according to Claim 40, characterized in that a laser diode is provided in order to illuminate the substrate surface, and an optical grating which is integrated in the pen.

30

42. Biometric writing system according to Claim 27, characterized in that the second optical sensor device (33) records the movements which are carried out by the pen, by comparison of the image sequences, recorded with a time

35



offset, of the substrate surface.

43. Biometric writing system according to Claim 27,  
characterized

5 in that the second optical sensor device (44) records  
the movements which are carried out by the pen (2) by  
comparison of the image sequences, which are recorded  
at time offsets, of the interference of the laser light  
which is reflected on the grating and on the substrate  
10 surface.

44. Biometric writing system according to Claim 27,  
characterized

in that, when it is in an extended state, the pen  
15 refill (2) emits a writing liquid to the substrate  
while carrying out the hand-guided movements, which  
writing liquid increases the optical structuring of the  
substrate surface over the ink written image on the  
substrate, so that optical recording of the hand-guided  
20 movements by means of the second optical sensor device  
(33) is simplified and a natural writing style is  
produced.

45. Biometric writing system according to Claim 23,  
25 characterized

in that the pressure sensor device (34) has  
electromechanical pressure sensors, which comprise  
piezoelectric, piezoresistive sensors, force-sensitive  
resistances and magnetic sensors.

30

46. Biometric writing system according to Claim 23,  
characterized

in that an inclination sensor (40) is provided, which  
comprises a miniaturized spirit level with an  
35 electrical tap for the angle change.

47. Biometric writing system according to Claim 3 and  
Claim 4,

TRI1\605845v1

characterized

in that the pen (2) is cylindrical and is mounted in the pen housing (3).

5 48. Biometric writing system according to Claim 47,  
characterized  
in that a pressure sensor is provided at the upper end  
of the pen (2) in order to record the forces and  
oscillations which occur in the longitudinal direction  
10 of the pen (2), with at least two further pressure  
sensors being provided on a circumferential surface of  
the pen (2) in order to record those forces which occur  
in the spatial directions which run orthogonally with  
respect to the longitudinal direction, and with a  
15 light-emitting diode (44) being provided at the upper  
end of the pen (2) in order to record the forces and  
oscillations which occur in the longitudinal and  
lateral directions of the pen (2).

20 49. Biometric writing system according to Claim 1,  
characterized  
in that the data processing unit (11) is integrated in  
a pen housing (3) or in an external receiving unit.

25 50. Biometric writing system according to Claim 49,  
characterized  
in that the external receiving unit is a computer, a  
mobile telephone, a credit card reader, a fax machine  
or a printer.

30 51. Biometric writing system according to one of the  
preceding claims,  
characterized  
in that the recorded sensor signal data is transmitted  
35 via a data transmission path (18) from the pen housing  
(3) to a data processing unit (19) which is integrated  
in a local computer (20).

52. Biometric writing system according to one of the preceding claims,  
characterized  
in that a scrambling unit (17) is provided in the pen  
5 housing (3) in order to scramble reference data for the sensor signal data.

53. Biometric writing system according to Claim 51,  
characterized  
10 in that the data transmission path (18) uses wires or is wire-free.

54. Biometric writing system according to one of the preceding claims,  
15 characterized  
in that a data memory is provided for storage of biometric reference data, position data for the writing movement, and spoken information.

20 55. Biometric writing system according to one of the preceding claims,  
characterized  
in that the biometric reference data is calculated by the data processing unit (11) from the sound signal  
25 data which is recorded while writing and speaking at least one word, from optical movement data, from mechanical oscillation and pressure data, and from inclination data, and is stored in a reference data memory.

30 56. Biometric writing system according to Claim 55,  
characterized  
in that the biometric reference data of the fingerprint sensor (39) is calculated by the data processing unit  
35 (11) and is stored in the reference data memory.

57. Biometric writing system according to one of the preceding claims,

TRI1\605845v1

characterized

in that the reference data memory is a microchip in an identity card, a credit card or an authorization magnetic card, or is a memory unit for a computer or  
5 for the writing system (1).

58. Biometric writing system according to Claim 55,  
characterized

in that the written and spoken words and characters are  
10 pin codes, passwords, names or texts.

59. Biometric writing system according to Claim 54,  
characterized

in that the position data for the writing movement is  
15 calculated from the sound signal data, optical movement data and mechanical pressure data recorded while writing a word, and is stored in the data memory for handwriting identification.

20 60. Biometric writing system according to Claim 55,  
characterized  
in that the reference data memory is integrated in the pen housing (3).

25 61. Biometric writing system according to Claim 51,  
characterized  
in that the data processing unit, which is integrated in a local computer (20), is connected to a reference data memory.

30  
62. Biometric writing system according to Claim 61,  
characterized  
in that the local computer (20) has a reading unit (26) for reading a portable memory medium for biometric  
35 reference data.

63. Biometric writing system according to Claim 61,  
characterized

TRI1\605845v1

in that the local computer (20) is connected via a data network (30) to a database with a reference data memory.

5    64. Biometric writing system according to Claim 63,  
characterized  
in that the data network (30) is the Internet.

10    65. Biometric writing system according to one of the  
preceding claims,  
characterized  
in that the data processing unit (11, 19) compares the  
calculated current biometric data with the stored  
biometric reference data in order to verify and  
15    identify it.

66. Biometric writing system according to Claim 65,  
characterized  
in that the data processing unit (11; 19) produces an  
20    identification and/or verification indication signal  
when the current biometric data largely matches the  
stored reference data.

25    67. Biometric writing system according to Claim 66,  
characterized  
in that the data processing unit (11; 19) identifies  
the current biometric data as a stolen copy of the  
stored reference data, and produces a warning signal,  
if the current biometric data completely matches the  
30    stored biometric reference data.

68. Biometric writing system according to Claim 66,  
characterized  
in that the data processing unit (11; 19) produces a  
35    discrepancy indication signal in the event of a  
discrepancy between the current biometric data and the  
stored biometric reference data.

69. Biometric writing system according to Claim 66,  
characterized

in that at least one actuator (28) is provided, which  
is operated after production of the identification  
5 and/or verification indication signal.

70. Biometric writing system according to one of the  
preceding claims,  
characterized

10 in that single characters which are currently being  
written are reconstructed by means of the stored  
biometric reference data for a person who has been  
identified or verified via the handwritten input.

15 71. Method for generation of personal-specific  
biometric reference data having the following steps:

(a) acoustic recording of hand-guided writing  
movements which are carried out by a person using  
a pen (2) on a substrate (4) while writing a  
20 character, a word or a word sequence, and  
production of corresponding sound signal data;

(b) storage of the sound signal data that is produced,  
as a digital sound time signal;

(c) calculation of associated frequency spectra as a  
25 spectrogram from the time-segmented sound signal  
data by means of a fast Fourier transformation;

(d) determination of amplitude time signals of  
selected frequencies in order to record the  
amplitude dynamics in the calculated spectrogram;

30 (e) calculation of an associated frequency spectrum  
from the selected amplitude time signals by means  
of fast Fourier transformation;

(f) determination of first biometric data from the  
sound and oscillation intensity of the digital  
35 time signals by means of feature extraction;

(g) determination of second biometric data from the  
calculated spectrogram of the time-segmented sound  
and oscillation time signals by means of feature

extraction;

(h) determination of third current biometric data by means of feature extraction from the calculated frequency spectrum of the amplitude time signals;

5 (i) determination of fourth current biometric data by means of feature extraction from recorded dynamic writing pressure, oscillation and inclination data.

10 72. Method according to Claim 71, characterized

in that the method steps are carried out two or more times and the respectively determined reference data is statistically evaluated, with the evaluated data being  
15 stored as personal-specific reference data.

73. Method according to Claim 72, characterized

in that the statistically evaluated personal-specific  
20 reference data is stored in a microchip in an identification card, in a microchip in a credit card, in an authorization magnetic card or in a memory unit for a computer or for a writing system.

25 74. Method according to Claim 71, characterized

in that the a speech signal which originates from that person is additionally acoustically recorded, and corresponding sound signal data is produced and stored.

30

75. Method according to Claim 74, characterized

in that, while the writing movement of the pen is being carried out, the forces which occur in at least one  
35 spatial direction are recorded via optical or mechanical pressure sensors, and at least one-dimensional writing pressure data is produced in a corresponding manner.

TRI1\605845v1

76. Method according to Claim 74,  
characterized

5 in that, while the writing movement of the pen (2) is  
being carried out, the writing speeds are recorded via  
a microphone (5) and at least one optical or mechanical  
oscillation sensor, and corresponding dynamic writing  
data is produced.

10 77. Method according to Claim 74,  
characterized

in that, while the writing movement of the pen is being  
carried out, the finger movements are recorded via at  
least one inclination sensor (40), and corresponding  
15 dynamic writing data is produced.

78. Method according to Claim 71,  
characterized

20 in that the writing movements, which are hand-guided on  
the substrate (4) while writing a character, a word or  
a word sequence with the pen, are recorded optically,  
and corresponding writing movement data is produced.

25 79. Method according to Claim 74,  
characterized

in that, while the writing appliance is being used,  
fingerprint data is recorded by means of a fingerprint  
sensor (39), which is integrated in the pen housing (3)  
and is stored.

30 80. Method according to Claim 71,  
characterized

in that biometric reference data is determined from  
sensor signal data by feature extraction in the time  
35 domain, space domain and frequency domain, and is  
stored in a reference data memory as personal-specific  
biometric reference data.



81. Method according to Claim 80,  
characterized  
in that data reduction of the sensor signal data is  
carried out by means of a cluster formation.

5

82. Method according to Claim 81,  
characterized  
in that feature parameters are extracted from the data-  
reduced cluster data.

10

83. Method according to Claim 82,  
characterized  
in that biometric reference data is selected from the  
feature parameters, for storage.

15

84. Method according to Claim 82,  
characterized  
in that current biometric data is obtained from the  
current feature parameters, for storage.

20

85. Method according to Claim 80,  
characterized  
in that the biometric reference data is stored inside  
or outside the writing appliance.

25

86. Method according to Claim 80,  
characterized  
in that the current biometric reference data is stored  
inside or outside the writing appliance.

30

87. Method for verification and identification of a  
person, having the following steps:

- (a) acoustic recording of hand-guided writing  
movements which are carried out by a person using  
a pen (2) on a substrate (4) while writing a  
character, a word or a word sequence, and  
production of corresponding sound signal data;  
(b) production of writing pressure signal data for the

35

- writing pressure and production of oscillation  
signal data for oscillations which are transmitted  
from the pen to at least one pressure and  
oscillation sensor;
- 5 (c) storage of the signal data that is produced at  
digital time signals;
- (d) calculation of frequency spectra as a spectrogram  
from the stored time-segmented sound and  
oscillation time signals by means of fast Fourier  
10 transformation;
- (e) determination of amplitude time signals of  
selected frequencies in order to record the  
amplitude dynamics in the spectrogram of the sound  
and oscillation time signals;
- 15 (f) calculation of an associated frequency spectrum  
from the selected amplitude time signals by means  
of a fast Fourier transformation;
- (g) determination of first current biometric data from  
the sound and oscillation intensity of the digital  
20 time signals by means of feature extraction;
- (h) determination of second current biometric data  
from the oscillation time signals by means of  
feature extraction;
- (i) determination of third current biometric data by  
25 means of feature extraction from frequency spectra  
of the amplitude time signals;
- (j) determination of fourth current biometric data by  
means of feature extraction from the dynamic  
writing pressure data, and;
- 30 (k) comparison of the current biometric data with  
stored biometric reference data for that person in  
order to verify whether the current biometric data  
largely matches the stored biometric reference  
data for that person;
- 35 (l) comparison of the current biometric data with  
stored biometric reference data for a large number  
of people in order to identify whether the current  
biometric data largely matches the stored

biometric reference data for one of the stored people.

88. Method according to Claim 87,  
5 characterized  
in that a speech signal which originates from the person is additionally acoustically recorded, and corresponding sound signal data is produced.

10 89. Method according to Claim 87,  
characterized  
in that the biometric data from the speech signal data is widened in conjunction with the writing signal data, for verification and identification.

15 90. Method according to Claim 87,  
characterized  
in that biometric data from a fingerprint sensor is additionally widened in conjunction with the writing  
20 and speech signal data, for verification and identification.

91. Method according to Claim 87,  
characterized  
25 in that biometric data from an inclination data sensor is additionally widened in conjunction with the writing and speech signal data, for verification and identification.

30 92. Method according to Claim 87,  
characterized  
in that biometric data from the dynamics of optically recorded position data is additionally widened in conjunction with the writing and speech signal data,  
35 for verification and identification.

93. Method according to Claim 87,  
characterized

TRI1\605845v1

in that the verification and identification are carried out from the acoustic writing and speech signal data by means of software for speaker and speech identification.

5

94. Method for handwriting identification and/or handwritten sketch identification according to Claim 87, characterized

10 in that the writing movements which are hand-guided on the substrate while writing or sketching a character, an image element, a word or a word sequence using the pen, are recorded acoustically and corresponding sound signal data is produced.

15

95. Method according to Claim 87, characterized

in that the writing movements which are hand-guided on the substrate while writing or sketching a character,  
20 an image element, a word or a word sequence using the pen are optically recorded, and corresponding position data is produced.

96. Method according to Claim 87, characterized

25 in that, while the writing movement of the pen is being carried out, forces which occur in at least one spatial direction are recorded optically or mechanically, and corresponding at least one-dimensional writing pressure  
30 data is produced.

97. Method according to one of the preceding Claims 87 to 96, characterized

35 in that a speech signal which originates from the person is additionally acoustically recorded, and corresponding sound signal data is produced.

98. Method according to one of the preceding Claims 87 to 96,  
characterized

5 in that reference feature vectors are determined in a training phase and the current feature vectors are determined in an operating phase for corresponding characters, sketches or words from the acoustic writing signal data, the optical position data, the writing pressure data and speech data, and are stored.

10

99. Method according to one of the preceding Claims 87 to 96,  
characterized

15 in that corresponding characters, image elements, sketches, word segments, words or word sequences are determined from feature vectors of the recorded signal data by means of statistical, connectionistic and knowledge-based methods.

20 100. Method according to one of the preceding Claims 87 to 96,  
characterized

25 in that the acoustic handwriting identification (ACR) the optical handwriting identification (OCR) and the speech identification are integrated in one and the same writing system, and the methods for image and text identification are combined with one another.

30 101. Method according to one of the preceding Claims 87 to 96,  
characterized

35 in that the features of the acoustic and optical data as well as pressure data are correlated in order to reconstruct entered characters, image elements, words and texts, and are then stored as feature vectors.

102. Method according to one of the preceding Claims 87 to 96,

characterized

in that characters, image elements, sketches, word  
segments, words or word sequences are determined in a  
corresponding manner from the correlated feature  
5 vectors of the recorded signal data by means of  
statistical, connectionistic and knowledge-based  
methods.

103. Method for handwriting identification and/or  
10 handwritten sketch identification according to Claim  
87,

characterized

in that the handwriting and handwritten sketch  
identification is carried out from the acoustic and  
15 optical writing and speech signal data by means of  
software for speech identification and image  
identification.

104. Method for handwriting identification and/or  
20 handwritten sketch identification according to  
Claim 87,

characterized

in that simple characters which are currently being  
written or simple image elements which are being drawn  
25 are reconstructed using the stored biometric reference  
data for an identified or verified person.

105. Method according to Claim 87,

characterized

30 in that the characters determined for the person  
producing them are fed back optically and/or  
acoustically in order to check them.

106. Method according to Claim 87,

35 characterized

in that the person-specific reference data generated  
from the determination of psychological and/or  
physiological features for the person is evaluated.

TRI1\605845v1

107. Use of the biometric acoustic writing system according to one of Claims 1 to 70 as a computer input device.

5

108. Use of the biometric writing system according to one of Claims 13 to 70 as a speech input device, in particular as a dictation machine.

10 109. Use of the biometric writing system according to one of Claims 1 to 70 for identification of motor-neurone movement disturbances of a person.

15 110. Use of the biometric writing system according to one of Claims 1 to 70 as a therapy system for treatment of motor-neurone movement disturbances of a person.

20 111. Use of the biometric writing system according to one of Claims 1 to 70 as a graphical system for determination of psychological/physiological features of a person.

25 112. Use of the biometric writing system according to one of the preceding Claims 1 to 70 as a training system for learning to write.

30 113. Use of the biometric writing system according to one of Claims 1 to 70 as a training system for learning to speak.

114. Use of the biometric writing system as a multifunctional computer input system for a virtual desktop.